

## **MECH 202 Spring 2011 Competition Project**

### **"Weeble® Rescue" (updated April 7, 2011 – Updates are highlighted in Yellow)**

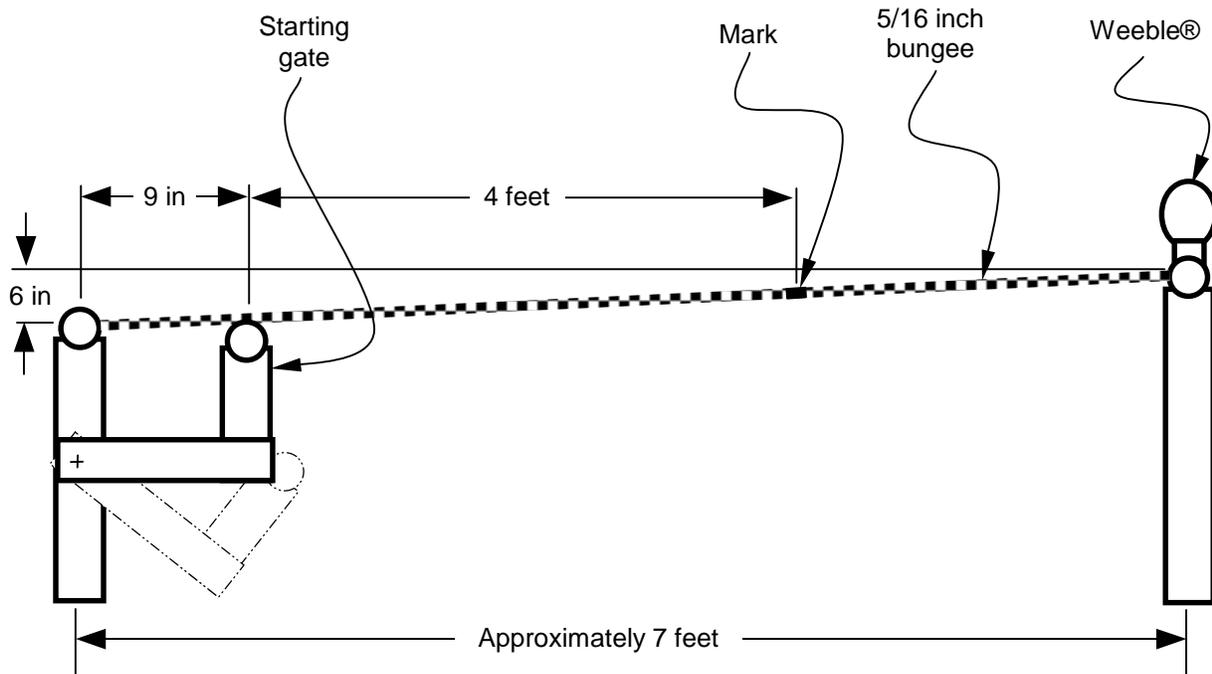
Your team is to design, fabricate, assemble and compete with a device that safely retrieves a Weeble® from the opposite side of a 7 foot chasm as well as satisfying the competition rules below. The MECH202 TA's are the "Judges of the Competition." Bob Thilmont and Bert Vermeulen will act as Chief Judges. Your team must also submit a report detailing your device and the process used to develop your design.

#### **The Time**

Saturday, April 23 starting at 10am in Eng 100. You should plan for this to take most of the day.

#### **Competition Overview**

1. The objective is to be the first team (of up to four in each round) to safely retrieve a Weeble® and return back to the starting zone.
2. Below is a conceptual (not to scale) drawing and a photo of the fixture under construction. A bungee cord is strung between two points 7 feet apart. The cord is about 6" lower at the starting area than at the side where the Weeble® (about 4 ounces) waits to be rescued. The cord is tensioned to deflect about 6" in the center under a 1 lb load. The fixture is made of PVC pipe and lumber.



3. The TA's will keep this fixture locked in A110 prior to race day. Your team should schedule with them to see and measure the fixture to ensure that your device will work correctly on it. You are not allowed to place your device on the competition fixture until the first time you compete on April 23.

### **Competition Details**

4. At the start of each round, devices will be placed on one of four bungee cords on the fixture. At the starting time your device can be a maximum of 8 inches measured in the direction of the bungee cord. There is a starting gate 9 inches from the starting end of the fixture. At the start of the round your device may only touch the starting gate and the bungee. Touching the pipe behind the device violates the 8-inch length.
5. The tasks your device must perform (in time-sequential order) are:
  - a. The entire device must move past a point 4-feet from the starting line (4 ft 9 inches from the pipe at the starting end of the bungee), which will be marked on the bungee;
  - b. The device must then pick up the Weeble®; and
  - c. The device must return safely to the starting zone (first 9 inches of the bungee) with its Weeble®.
6. At no time during a round should your device extend more than 10 inches below the bungee cord or 10 inches above the bungee cord, or more than 8 inches on either side of the bungee cord. This creates a 16-inch wide by 20-inch tall envelope within which your device must stay.
7. You must place your device on the fixture in the starting area and step away. Your device must use the opening of the starting gate as its signal to move forward.
8. Once the starting gate has opened, your device can enlarge itself in a direction parallel to the bungee, so long as it stays a single device. The fact that it must stay as a single device means that you cannot use remote control (a remote control would make it not a single device). Note however, that the entire device must move past the 4-foot point (see #4 below) and the maximum width and height of your device can never exceed the dimensions provided in #6.
9. Each round of the contest is 45 seconds long. At the end of the round, the devices will preferably be stopped or stop themselves.
10. Safety is paramount. Any device that drops its Weeble®, causes it to fall from the retrieval point, or damages a Weeble® will be completely eliminated from the competition. In the real world, that device would not be able to get insurance after causing a fatality.
11. If more than one device in a round safely accomplishes all tasks identified in #4, and does not violate any other rules, the device that completes all tasks first will be declared the winner of that round. Other devices will be ranked based on the time when they finish (within the 45 seconds) or how many of the tasks they accomplish as described below.
12. If only one device safely completes all of the tasks identified in #11, and does not violate any other rules, that device will be declared the winner of that round. Other devices will be ranked based on how many of the tasks they accomplish.
  - a. As mentioned before, devices that cause a Weeble® fatality are ranked lowest and eliminated.
  - b. Devices that came apart or fell off the fixture are ranked next lowest.
  - c. Devices that met none of the tasks listed in #11 (or only moved on the bungee, but did not pick up the Weeble®) will be ranked next lowest and will be ranked based on the distance moved by the furthest back part of the device.
  - d. Devices that safely picked up the Weeble®, but did not return completely to the starting zone will be ranked highest (but below fully successful devices), based on the distance between the Weeble® and the starting zone at the end of the 45-second period.
  - e. In case of a tie based on the above criteria, the lightest device will be judged to be superior.

### Other Rules and Information

13. Other than teams that are eliminated due to a fatality of their Weeble®, the competition will be “double elimination” so each team will have at least two chances to participate. Details of how the heats and how the winners and losers move from round to round will be available prior to the day of the competition. Only the first place winners will advance to the next round.
  14. Your device cannot touch any of the tubing of the fixture except: (a) the starting gate at startup, (b) in the region where the Weeble® is to be picked and (c) back in the starting area after returning with the Weeble®. Your device should not intentionally touch any other device during the competition.
  15. Your device cannot get energy from the bungee. It may clamp the bungee in a non-damaging way..
  16. For practical and safety reasons related to the strength and deflection of the bungee cord, your device can weigh no more than 2 lbs.
  17. You are encouraged to build your own test fixture. We deliberately made our fixture from standard low cost parts to facilitate duplication of the key elements for our testing. A parts list is provided in Appendix B.
  18. Keep in mind that the components used to make the competition fixture will not be perfect or exactly like a test fixture that you might fabricate from the same parts. It is important that your device can tolerate these types of differences. This is part of having a robust design.
  19. Your device can be made from any materials that you would like to use. However, you cannot use any energy storage method or device that might be deemed hazardous. Examples of hazardous energy storage devices include, but are not limited to:
    - Explosives, combustion processes, or highly exothermic reactions (such as model rockets).
    - A compressed fluid that might release too quickly
    - Anything deemed to be unnecessarily harmful to either the fixture or another competitor’s device.
- The TA’s will serve as “OSHA” safety inspectors. You will need their certification from a safety inspector before noon on Friday, April 22. It is in your interest to contact the safety inspectors early to ensure that you do not waste time on a device that may not be certifiable.
20. If your team is not willing to stand next to your device without protective clothing or safety glasses, your device will be considered hazardous! However, since some individuals are braver than others. The judges reserve the right to deem a device hazardous.
  21. No human contact with the device is allowed at any time during the time from the start of a round until that round has finished.
  22. The device cannot contain any biological components. For example, you are not allowed to employ a trained squirrel to retrieve the Weeble®.
  23. Electric motors. In the past a high percentage of devices have used electric motors. This is fine, but can run up the cost and weight of your device. We have tried deliberately to try to keep the cost of this competition as low as possible. We encourage teams to come up with elegant low-cost ways to meet the requirements that do not require motors. We have also obtained a supply of 6V DC motors with reduction gears. There is one of these motors available for any team that would like one. Appendix C provides the specs for these motors. They appear to weigh about 2 ounces.
  24. ANY intentional attempt to damage the opponent in lieu of meeting the objectives of the competition will be grounds for disqualification. In the case of destruction deemed by the judges to be accidental, but severe enough to unfairly influence the competition’s outcome the judges may permit repairs and a rematch.

25. Can your device disrupt other devices? No, you would forfeit that round if the disruption was judged to be intentional. The round would be rerun if it was judged to be accidental. If it accidentally occurred in two successive runs, you would be disqualified even if it was unintentional.
26. Each round will have a maximum of five minutes for you to place your device onto the fixture, move away prior to the start, compete and remove the device from the fixture
27. Your team must check into the registration table 15 minutes prior to your round. Failure to do so will result in a forfeit for that round. Once your round is complete you will need to track your team's placement on the bracket sheet and note the time of your next competition. You will be responsible to be ready on time for subsequent rounds based on the brackets you are assigned. If you fail to show up to your respective round you will forfeit that round.
28. Weebles® are commercially available from many local toy stores. Playskool originally produced the product and they are now a division of Hasbro. I was able to buy 6 Weebles for \$11 at Walmart. They can also be purchased in packs of 2 for \$6. There may be slight variations in the different models, so you need to make sure your device can handle these variations.
29. Damaging the fixture. Your team will be disqualified if your device intentionally or unintentionally damages the fixture in any manner including but not limited to: breaking any part of the fixture, generating noticeable nicks or notches that will impact the integrity of the competition, adding foreign substances such as oil or lubricants onto the fixture.
30. Protests. All protests must be registered immediately after the competing round. You must qualify your protests based on the ground rules and the project definition. Keep good engineering records (engineering book) of your development process to use to defend your positions. If you have no supporting documentation at the day of the competition, your protest will be disallowed. Bert Vermeulen will be the final judge on all protests.
31. And keep in mind. This competition is a lot of fun and an opportunity to cheer and encourage everyone. Feel free to invite your friends and family as well. You can see elements of last two year's competitions at [www.mech202.com](http://www.mech202.com).
32. Can we use a spring? There's no problem in using a spring, rubber band, or other means of propulsion as long as it does not generate so much force as to be dangerous. Using a cross-bow, for example would be considered dangerous because we don't think any of your team members would feel safe standing in front of it.
33. Can we grab our device after it completes the task? Not until the round has been declared completed. Please ensure that your device cannot fall of the bungee and damage itself.
34. Will there be any changes made to the competition fixture prior to April 23? We may make minor improvements to ensure that the fixture is stable and raceworthy. These changes may slightly affect the geometry of the fixture and the starting gate, but not alter any of the fundamental functionality.

### **Judges Decisions Disclaimer**

In a competition of this nature it is hard to anticipate all the interpretations of the rules and situations that will arise in the competition. Therefore, anything not covered by these rules and the interpretations of the rules will be decided by the judges. These rules are subject to optimization, and may be altered by the staff to preserve the "spirit" of the contest.

## The Rewards

1. The winning team will receive an A for the course and will not have to take the final examination
2. The 2nd place team will receive an A for the project and a 100 for the final
3. The 3rd place team will receive an A for the project

Note that all three winning teams must be present during the lecture on April 26, as we may ask you to help explain to others in the class how you designed your device and some of its more successful features.

We will ask other faculty members to help judge the devices for other areas of merit, which might include:

- Manufacturing craftsmanship.
- The use of mechatronics.
- Design simplicity and elegance
- Low cost

## The Lead Up

Your design group may ask any questions whatsoever of Bob Thilmont, Bert Vermeulen or the TAs. This is strongly encouraged to ensure that your device meets the spirit of the competition. We encourage you to use RamCT to ask these questions. If you email questions to us, these questions and their answers will be posted on RAMCT. If you have any of us sign a "non-disclosure agreement" (sample attached), we will then discuss with you confidentially those issues you have, and will not disseminate your questions or the answers to the entire class.

## Q & A (31-March 2011)

The following are frequently asked questions and their answers. The numbers are a continuation of the numbering on page 4.

- 35. How far beyond the end of the fixture can our device extend in the region where the Weeble® is located?** Your device can extend up to 10 inches beyond the end of the fixture (as measured from the center of the Weeble® stand).
- 36. Please clarify whether Rule 10 (page 2 above) allows the Weeble® to become airborne in the process of retrieving it.** The Weeble® may become airborne during a round so long as it is caught unharmed by your device and your device and the Weeble® are never outside of the specified design envelope (8" on each side of the bungee, 10" above or below the bungee, and no more than 10" beyond the retrieval end of the fixture). Note that Weeble® movement methods relying solely on inertia are considered high risk as it is not possible to predict the motions of the bungee or the fixture during a round, just like it's not possible to predict earthquakes when building a nuclear power plant. Your team is responsible for any casualties resulting from a Weeble® retrieval system with inadequate safety margins to handle the "real world" dynamics of the fixture during competition.
- 37. Can we calibrate our device to the particular lane we are operating in?** No, you must make your device capable of operating in any lane without any adjustments. You also cannot select which Weeble® you will be retrieving or offer us your Weeble® as the one you'd like to retrieve.
- 38. Can any foreign substance be applied to a Weeble® in the retrieval process?** No substance can be applied to a Weeble® that would require a "cleaning" process of any type after the finish of a round. The TA's should be able to cleanly remove the Weeble® from your device at the end of the round without needing to do any special cleaning, rubbing or scraping operations. If your device leaves any residue on the Weeble® when it is removed from your device, you will forfeit this round.
- 39. Is the bungee 5/8" or 5/16" in diameter.** Appendix B had a typo, now fixed. The bungee is 5/16" in diameter.
- 40. How will the 4' point on the fixture be marked?** With magic marker.

## Q & A (7-April 2011)

The following are further questions asked during the last week that are of relevance to all groups.

41. **Can we use a compressed CO<sub>2</sub> cylinder?** This will depend upon the size of the cylinder and the safety systems you've built to ensure that nothing hazardous can occur. If you are contemplating anything that might be potentially hazardous, you should submit your design to the TAs for a safety review as early as possible to ensure that there are no disappointments. The general rule is that if you feel uncomfortable standing next to your device in normal springtime clothing without safety glasses on, it is definitely unsafe. The TAs will be close to the fixture during the round and it therefore must be completely safe for them. It is also important that there is no possibility of anything coming off of your device that might land anywhere other than immediately under the fixture.
42. **What parts of the starting gate tube can our device touch at that start of the round?** Your device can touch the starting gate (a PVC tube) anywhere on the half of the tube that faces the starting zone and the top of the starting gate so long as it does not disrupt the opening of the starting gate and so long as your entire device is no longer than 8 inches when you start. Keep in mind that trying to use the top of the starting gate will cause the bungee cord to move up, which is not recommended. You must also be careful not to interfere with the opening of the starting gate, so it is useful to know the path that the starting gate will take when it drops.
43. **Must our device stay in the starting area (first 9 inches of bungee) once it returns?** It is sufficient for the Weeble to enter the starting zone as long as the Weeble is not dropped after you enter the starting zone. Your device does not need to retract to 8 inches and your device does not all need to return to the starting zone, but your device must stay as a single device and no part of your device may ever be more than 8 inches on either side or 10 inches above or below the bungee. You cannot accidentally or on purpose leave any part of your device anywhere or have it drop. The device must also stay in the starting zone after it enters it. The Weeble® must completely enter the starting zone and must completely stay there until the end of the round is declared. If your device drops its Weeble® after entering the starting zone and before your team is allowed to access your device at the end of the round you will still be disqualified. You must make sure that your device is so safe that it will not drop its Weeble under any circumstances. Think of Weebles® as being like people and dropping them as being like creating a fatality. You must do everything you can to prevent those fatalities.
44. **Can we turn our device off when it enters the starting area?** Your team will be away from the starting zone when the round starts and must stay away from the starting zone until the entire round is over. Therefore, you cannot turn your device off once it returns to the gate. If one device returns and the others are also on the way, the audience will want to see how well the other devices do. If you got close to the starting area, you would block their view. So, please make a device that stops itself when it gets to the starting area or encounters the starting end of the fixture in a way that does not damage the fixture.
45. **What type of Weebles® will be used for the competition?** The Weebles® for the competition will be purchased at WalMart and either be from a Playskool Weebles Collector 6-pack or something equivalent.

## Required Report

If you did not get one of the top three places in the competition, your grade for this project will be based on the report that you submit. Your competition outcomes will not affect the grade of the report unless you place in one of the top 3 positions. The report will be turned in at the time of the competition, the first time your device runs on the fixture. Please bind the report in a professional manner and also put an electronic (PDF) version of the report into the Drop Folder. Both versions must be in before 10am on the day of the competition. The report will consist of:

Page 1:

- Names and contact emails for each member of your group
- A title identifying the device
- A photo of the device to fit in the remainder of the space of page 1

Report:

1. A project plan and documentation showing the relationship between actual completion of project tasks versus plan. This needs to include an estimate of the hours spent by each team member on the project.
2. Documentation showing the process used to develop the specification for your device.
3. The specification you designed the device to meet. This should be in your own words, drawings, charts, equations, etc. It can use material provided in this document but should include other items that you thought were relevant. Your specification should attempt to quantify as much as possible using measurements that can later be verified. Please include how you prioritized the musts and wants in your specification.
4. An engineering analysis of the physical and technical challenges the device needed to overcome.
5. A description of the design alternatives you considered and the process used to make the design decisions needed to make to address the physical and technical challenges your team identified.
6. A set of drawings that show how your device functions. These don't need to be Pro/E drawings and they don't need all details. There needs to be text to accompany these drawings that explains the illustrations in sufficient detail so that anyone "skilled in the art" (i.e. another student in this class) could buy the necessary components and fabricate a device that functioned similarly to your device. This section should include a bill of materials that lists the cost of each item required to fabricate your device and where this item might be obtained.
7. A description of testing that you did to verify that your device would perform well in the competition. This should include a description of things you learned during these tests and improvements that you made as a result of testing.
8. A safety analysis of your design or design choices showing risks and what your team did to minimize the most critical hazards.
9. A reliability analysis of your design or design choices showing the places where you believe your device is most likely to fail and what you have done to build design margin into those areas.
10. A service and support plan for your device in case any part of your device should fail and you need to make emergency repairs.

## Post Mortem

By Monday evening April 25 (at 11pm), all groups that did not win first second or third place should turn in brief post-mortem listing five – ten things they learned from the competition. The teams that won one of the top three places may also turn in something if they like. Doing a post-mortem is a good idea for any

project. This will also be part of your grade for the project. More details of the content of the post-mortem will be provided prior to the due date.

**APPENDIX A.**

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**Request for Confidentiality** (use if you need to share info with TA's or Instructors)

The undersigned agrees to hold confidential information of a competitive nature with the group members listed here. If the discussion leads to items of general interest (eg. – rules, competition or grading clarification), the design group allows publication of those items of general interest. Otherwise, any discussion of a competitive nature leading to a competitive advantage for the group will be held confidential.

Signed:

Dated:

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## **APPENDIX B. Fixture Parts List**

Below is an indicate list of parts used to build the main parts of the competition fixture. Note that your test fixture can be substantially less expensive since you do not need to build one that had four lanes. All of the parts in the table below are available at Home Depot.

Part	Part Number	Price	Quantity	Total
3/4" x 10' SCH 40 PVC	A 193-712	\$1.73	5	\$8.65
3/4" SCH 40 PVC "T" fitting	B 187-917	\$0.33	14	\$4.62
3/4" SCH 40 PVC 90 <sup>0</sup> Elbow	B 187-976	\$0.34	12	\$4.08
8oz Purple PVC Primer	B 391-417	\$5.10	1	\$5.10
8oz PVC Cement, Regular, Clear	B 187-100	\$4.22	1	\$4.22
2"x4" - 96" Hem Fir Stud	A 161-640	\$2.11	8	\$16.88
Misc Supplies (Screws, etc.) *NOTE: Estimation	N/A	\$15.00	1	\$15.00
			Total	\$58.55

The bungee cord is **5/16"** and should be available from Jax Outdoor Gear in Fort Collins. It has been spotted at Jax in Loveland. It is also available at McGuckins in Boulder (if you cannot find it anywhere else).

Note that the above does not include the wood base or starting gate, the details of which were not available at press time, but can be seen when looking at the actual competition fixture. The starting gate is also made using a 3/4" PVC fitting at the point of contact with your device.

### **APPENDIX C. Electric Motors**

An anonymous donor has contributed small DC motors to the Mechanical Engineering department for use on student projects. We have enough motors to give each team one motor that they can use for their second project. The motors operate at 6V and include a reduction gear that provides a speed of about 90 RPM at 6V no load.

Each team is entitled to 1 motor. If you burn it out, there's no spare and the motors themselves are pretty pricey to buy.

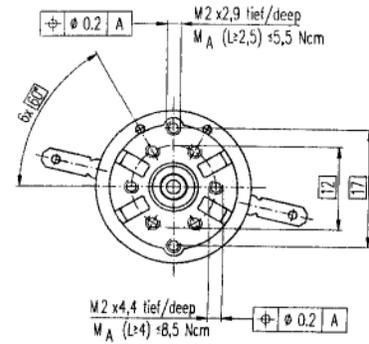
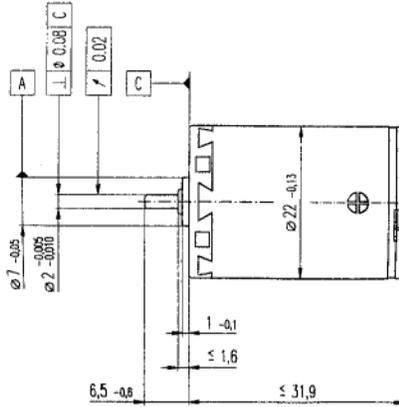
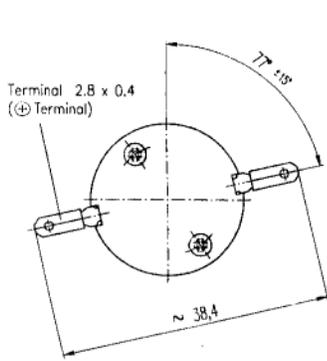
We don't necessarily recommend that you use an electric motor for your second project. You'll need to do your analysis to determine whether to use an electric motor and whether this would be the motor that you want to use. Remember that the heavier your device, the more the bungee will sag. We haven't weighed them, but the motors appear to be about 2 ounces.. If you decide to use one of these motors, please include your engineering analysis of why you chose to use this motor.

The motors can be picked up in the TA's office.

The next two pages provide the specs on the motor. It is a Maxon 110117. The reduction gear appears to be a spur gear. Based on measurements made, we believe the spur gear is either providing a 64:1 or a 131:1 reduction.

# A-max 22 Ø22 mm, Precious Metal Brushes CLL, 5 Watt, CE approved

maxon DC motor



M 1:1

- Stock program
- Standard program
- Special program (on request)

Order Number		
110117	110119	110120

## Motor Data

Values at nominal voltage		
1	Nominal voltage	V 6.0
2	No load speed	rpm 9640
3	No load current	mA 29.6
4	Nominal speed	rpm 7480
5	Nominal torque (max. continuous torque)	mNm 4.81
6	Nominal current (max. continuous current)	A 0.840
7	Stall torque	mNm 21.5
8	Starting current	A 3.65
9	Max. efficiency	% 83
Characteristics		
10	Terminal resistance	Ω 1.64
11	Terminal inductance	mH 0.106
12	Torque constant	mNm / A 5.90
13	Speed constant	rpm / V 1620
14	Speed / torque gradient	rpm / mNm 452
15	Mechanical time constant	ms 19.1
16	Rotor inertia	gcm <sup>2</sup> 4.04

## Specifications

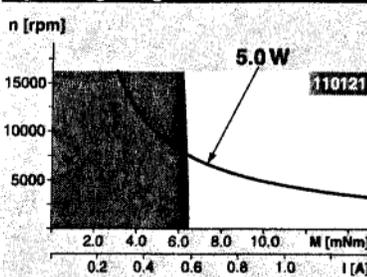
Thermal data		
17	Thermal resistance housing-ambient	20 K / W
18	Thermal resistance winding-housing	6.0 K / W
19	Thermal time constant winding	10.1 s
20	Thermal time constant motor	540 s
21	Ambient temperature	-30 ... +65°C
22	Max. permissible winding temperature	+85°C
Mechanical data (sleeve bearings)		
23	Max. permissible speed	16000 rpm
24	Axial play	0.05 - 0.15 mm
25	Radial play	0.012 mm
26	Max. axial load (dynamic)	1 N
27	Max. force for press fits (static)	80 N
28	Max. radial loading, 5 mm from flange	2.8 N
Mechanical data (ball bearing)		
23	Max. permissible speed	16000 rpm
24	Axial play	0.05 - 0.15 mm
25	Radial play	0.025 mm
26	Max. axial load (dynamic)	3.3 N
27	Max. force for press fits (static)	45 N
28	Max. radial loading, 5 mm from flange	12.3 N
Other specifications		
29	Number of pole pairs	1
30	Number of commutator segments	9
31	Weight of motor	54 g
CLL = Capacitor Long Life		

Values listed in the table are nominal.  
Explanation of the figures on page 49.

## Option

- Ball bearings in place of sleeve bearings
- Pigtails in place of terminals
- Without CLL

## Operating Range

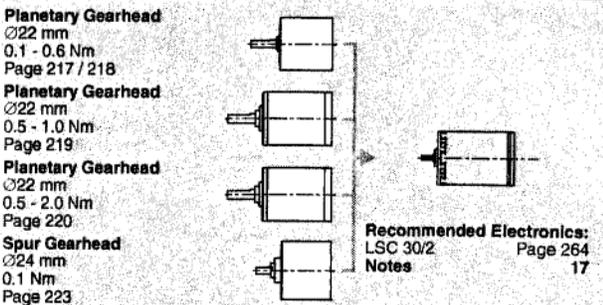


## Comments

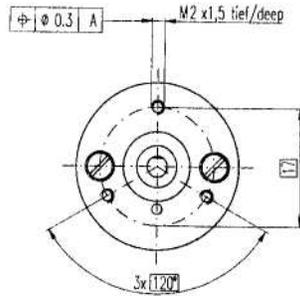
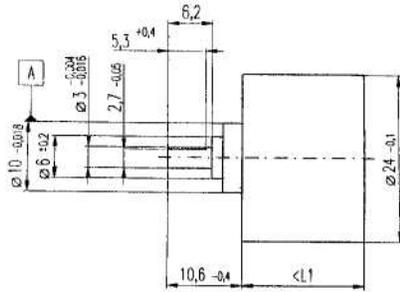
- Continuous operation**  
In observation of above listed thermal resistance (lines 17 and 18) the maximum permissible winding temperature will be reached during continuous operation at 25°C ambient.  
= Thermal limit.
- Short term operation**  
The motor may be briefly overloaded (recurring).
- Assigned power rating**

## maxon Modular System

Overview on page 17 - 21



# Spur Gearhead GS 24 $\varnothing 24$ mm, 0.1 Nm



M 1:1

## Technical Data

Spur Gearhead	straight teeth
Housing	plastic
Output shaft	stainless steel, hardened
Bearing at output	sleeve bearing
Radial play, 8 mm from flange	max. 0.038 mm
Axial play	0.03 - 0.30 mm
Max. radial load, 8 mm from flange	5 N
Max. permissible axial load	8 N
Max. permissible force for press fits	500 N
Average backlash no load	< 2.5°
Recommended input speed	< 4000 rpm
Recommended temperature range	-20 ... +100°C
Extended area as option	-35 ... +100°C

maxon gear

- Stock program
- Standard program
- Special program (on request)

## Order Number

	110480	110481	110482	110483	110484	110485	110486
1 Reduction	7.2 : 1	20 : 1	32 : 1	64 : 1	131 : 1	199 : 1	325 : 1
2 Reduction absolute	$\frac{93}{13}$	$\frac{121915}{8153}$	$\frac{151813}{4696}$	$\frac{837}{13}$	$\frac{212629}{1825}$	$\frac{778642}{3906}$	$\frac{1093365}{3382}$
3 Max. motor shaft diameter mm	2	2	2	2	2	2	2
4 Number of stages	2	4	4	4	4	6	6
5 Max. continuous torque Nm	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6 Intermittently permissible torque at gear output Nm	0.15	0.15	0.15	0.15	0.15	0.15	0.15
7 Sense of rotation, drive to output	=	=	=	=	=	=	=
8 Max. efficiency %	81	66	66	66	66	53	53
9 Weight g	25	28	28	28	28	30	30
10 Average backlash no load °	1.0	2.0	2.0	2.0	2.0	3.0	3.0
11 Mass inertia gcm <sup>2</sup>	0.008	0.01	0.008	0.007	0.006	0.008	0.006
12 Gearhead length L1* mm	13.7	17.4	17.4	17.4	17.4	21.2	21.2

\*for A-max 19 is L1 + 2.8 mm



## Combination

+ Motor	Page	+ Tacho / Brake	Page	Overall length [mm] = Motor length + gearhead length + (tacho / brake) + assembly parts						
A-max 19	105/106			45.5	49.2	49.2	49.2	49.2	53.0	53.0
A-max 19, 1.5 W	106	MR	243/244	50.6	54.3	54.3	54.3	54.3	58.1	58.1
A-max 19, 1.5 W	106	Enc 22	249	59.9	63.6	63.6	63.6	63.6	67.4	67.4
A-max 19, 1.5 W	106	MEnc 13	258	53.0	56.7	56.7	56.7	56.7	60.5	60.5
A-max 19	107/108			48.1	51.8	51.8	51.8	51.8	55.6	55.6
A-max 19, 2.5 W	108	MR	243/244	52.4	56.1	56.1	56.1	56.1	59.9	59.9
A-max 19, 2.5 W	108	Enc 22	249	62.5	66.2	66.2	66.2	66.2	70.0	70.0
A-max 19, 2.5 W	108	MEnc 13	258	55.6	59.3	59.3	59.3	59.3	63.1	63.1
A-max 22	109-112			45.7	49.4	49.4	49.4	49.4	53.2	53.2
A-max 22	110/112	MR	243/244	50.7	54.4	54.4	54.4	54.4	58.2	58.2
A-max 22	110/112	Enc 22	249	60.1	63.8	63.8	63.8	63.8	67.6	67.6
A-max 22	110/112	MEnc 13	258	52.8	56.5	56.5	56.5	56.5	60.3	60.3